

UNITED STATES AIR FORCE RESEARCH LABORATORY

INTERLABORATORY STUDY (ILS) FOR F 548-01, THE STANDARD TEST METHOD FOR INTENSITY OF SCRATCHES ON AEROSPACE TRANSPARENT PLASTICS

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TECHNICAL REVIEW AND APPROVAL

AFRL-HE-WP-TR-2003-0009

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER



MARIS M. VIKMANIS
Chief, Crew System Interface Division
Air Force Research Laboratory

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6. AUTHOR(S) Alan R. Pinkus* Martha A. Hausmann**					
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13. ABSTRACT (Maximum 200 words) Scratches exist on all transparent plastic surfaces. Usually, cleaning procedures cause very fine scratches that are not visible when looking through the plastic. Visible scratches may be distracting to an observer looking through an aerospace transparent plastic. Therefore, a procedure to define scratches is useful. A visual comparison is made between a set of graded scratch standards and a scratch on the plastic transparency to determine its relative intensity. A visual standard is used because it is not practical to measure the dimensions of the fine scratches.					
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1. TITLE

INTERLABORATORY STUDY (ILS) FOR F 548-01, THE STANDARD TEST METHOD FOR INTENSITY OF SCRATCHES ON AEROSPACE TRANSPARENT PLASTICS

Committee F-7 on Aerospace and Aircraft Enclosures

Subcommittee F-7.08 on Transparent Enclosures and Materials

RR: F07-1007

2. INTRODUCTION

The American Society for Testing and Materials (ASTM) develops and publishes standardized test methods. Each test method requires a precision and bias statement so organizations that apply the method know its inherent reproducibility (between-laboratory variability) and repeatability (within-laboratory variability). Reproducibility and repeatability for this test method were determined by conducting an interlaboratory study (ILS) as outlined in ASTM E 691. This report, which conforms to the ILS reporting format required by ASTM, describes the study that was conducted for ASTM test standard F 548-01, Intensity of Scratches on Aerospace Transparent Plastics.

Scratches exist on virtually all transparent plastic surfaces. Usually, cleaning procedures cause very fine scratches that are not visible when looking through the plastic. Visible scratches may be distracting to an observer looking through an aerospace transparent plastic. Therefore, a procedure to define scratches is useful. A visual comparison is made between a set of graded scratch standards (adjuncts) and a scratch on the plastic transparency to determine its relative intensity. A visual standard is used because it is not practical to measure the dimensions of the fine scratches.

3. TEST METHOD

See ASTM F 548-01, Standard Test Method for Intensity of Scratches on Aerospace Transparent Plastics

4. LIST OF PARTICIPATING LABORATORIES

AFRL/HECV

2255 H St. Room 300

Wright-Patterson AFB, OH 45433-7022

University of Dayton Research Institute

300 College Park Ave.

Dayton, OH 45469-0110

PPG Industries, Inc.

1719 E. Highway 72

Huntsville, AL 35811

5. INTERLABORATORY TEST PROGRAM INSTRUCTIONS

Cover letter for test instructions to participating laboratories:

Subject: ASTM Interlaboratory Study (ILS) for Measuring Intensity of Scratches on Aerospace Transparent Plastics

To: Participating Organization

From: Alan Pinkus

AFRL/HECV, 2255 H St. Room, 300

Wright-Patterson AFB OH 45433-7022

Dear Colleague,

As part of ASTM Committee 7.08 standards writing activity, we are conducting an ILS in order to ascertain the precision of Standard Test Method for Intensity of Scratches on Aerospace Transparent Plastics, F 548-01. Since this method has a numerical result, it requires a precision statement. After the ILS, F 548-01 will be revised to include a precision statement.

You recently took part in an ILS for judging the intensity of scratches in glass. This study has essentially the same format except it is for judging the intensity of scratches in plastic. Your participation in this study is greatly appreciated. No data will be released with any company or individual identification labels. The data in the ILS report to ASTM are given generic labels and the final precision statement uses only summary statistics as outlined in ASTM E691 and ASTM E 177. If there are any questions, please do not hesitate to contact Alan Pinkus (937-255-8767) or Martha Hausmann (937-255-1205).

Sincerely,
Alan Pinkus, Ph.D.

6 Attachments:

1. ASTM F 548-01 Standard Test Method
2. Aerospace Scratch Adjuncts for Plastic
3. 16 Plastic Scratch Samples
4. Test Instructions
5. Data Sheet
6. Return Address Label

Test Instructions:

Your task is to determine the scratch intensity levels of different scratch samples.

1. Complete the background information on the data sheet.
2. There are 16 plastic scratch samples and 8 scratch test standards. The 16 plastic scratch samples to be compared to the scratch test standard and rated are labeled A through P. The 8 scratch test standards are labeled 11 through 18. **Caution:** *this ASTM standard costs \$1500.*
3. Please refer to the attached standard F 548-01 for the test methodology. Beginning with **trial #1** on the data sheet, select the designated **scratch sample** (A through P) and place in an angled position to allow for optimum visual definition of the scratch. *Please handle the scratch samples and standard by the edges only to avoid getting fingerprints on them.* If they become dirty, carefully wipe using the supplied cloth. The light level required for judgment is a minimum of 80 lux. Natural or artificial light may be used. Determine the rating of the

scratch sample by comparing it to the scratch test standard by placing the test standard next to the scratch sample, one at a time. Select the test standard rating (11 through 18) that most closely matches the scratch sample. Disregard scratch lengths. Record the scratch level number in the **rating** column located on the data sheet. Repeat this procedure for all 80 trials.

4. Return your data sheet, the plastic scratch samples and the scratch adjunct to Alan Pinkus, AFRL/HECV, 2255 H St, Room 300, Wright-Patterson AFB OH 45433-7022 (937-255-8767). Note: The packaging has been designed for reuse for both your convenience and to assure full protection of the delicate test pieces. A return address label has been included. Please insure the contents for \$1500. Please complete your portion of the ILS as quickly as possible because many companies are participating in this large study.

Sample Data Sheet:

ASTM Intensity of Scratches in Plastic Interlaboratory Study Data Sheet					
Initials:			Observer #:		
Date:					
Organization:					
Trial#	Scratch Sample	Rating	Trial#	Scratch Sample	Rating
1			41		
2			42		
3			43		
4			44		
5			45		
6			46		
7			47		
8			48		
9			49		
10			50		
11			51		
12			52		
13			53		
14			54		
15			55		
16			56		
17			57		
18			58		
19			59		
20			60		
21			61		
22			62		
23			63		
24			64		
25			65		
26			66		
27			67		
28			68		
29			69		
30			70		
31			71		
32			72		

33			73		
34			74		
35			75		
36			76		
37			77		
38			78		
39			79		
40			80		

6. DATA REPORT FORMS

See Appendix A

7. STATISTICAL DATA SUMMARY

Fifteen trained observers rated 16 plastic scratches. Each scratch was rated five times by each observer. The 80 trials for each observer were randomized with the constraint that there be at least 10 trials between replications of the same scratch. Observers were provided adjuncts that had scratch ratings of 11, 12, ..., 18 (11 the thinnest, 18 the thickest). For an individual trial, the observer would place 1 of the 16 scratches next to the adjuncts and determine the closest match. Figures 2a and 2b show the number of trials for each observer and scratch having a particular scratch rating.

Table 1 shows the judged rank-order of the plastic scratch samples. Figure 1 contains the percent of the 75 total trials (15 observers times five replications) for each scratch having a particular scratch rating.

Table 1. Rank-order of plastic scratch samples.

Scratch	Mean Rating (N = 75)
K	11.5
E	11.6
O	11.8
A	12.5
I	12.6
L	13.0
C	13.4
B	14.0
F	14.7
G	15.5
N	15.6
D	16.2
M	16.7
J	16.9
P	17.2
H	17.9

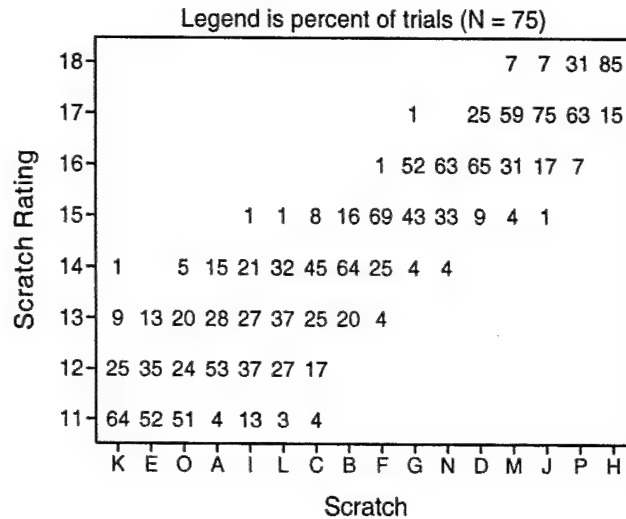


Figure 1. Percent of all trials for each scratch (N = 75) having a particular scratch rating.

Of interest is how consistently the observers rated each scratch for their five replications and how close scratch ratings were from one observer to another. For continuous variables, repeatability and reproducibility limits could be determined using the normal distribution where 95th percentiles for absolute difference in trials are estimated. The discrete ratings in this data does not lend itself to this type of analysis. Instead, the percent of all absolute differences in trials, both within and between observers, was calculated for each possible absolute difference (i.e., 0 to 7). Results are shown in Table 2. Cumulative percents are shown in Table 3.

Table 2. Mean rating across all observers and trials (N = 75) and percent of absolute difference in trials both within (N = 15 observers * 10 paired reps per observer = 150) and between (N = 15 observers * (5 reps * 70 other trials)/2 = 2625) observers.

Scratch	Mean Rating (N = 75)	Percent of Absolute Difference in Trials									
		Within Observers (N = 150)					Between Observers (N = 2625)				
		0	1	2	3	4	0	1	2	3	4
K	11.5	80.0	17.3	2.7			45.7	39.1	13.4	1.8	
E	11.6	70.0	29.3	0.7			38.3	46.9	14.8		
O	11.8	64.0	34.7	1.3			33.2	36.6	24.4	5.8	
A	12.5	64.0	32.0	4.0			36.3	43.5	18.9	1.3	
I	12.6	56.7	35.3	4.0	3.3	0.7	24.7	42.8	25.2	7.0	0.3
L	13.0	58.7	38.0	2.7	0.7		28.8	47.2	21.3	2.6	0.1
C	13.4	67.3	30.7	2.0			27.7	41.5	23.2	6.9	0.7
B	14.0	73.3	24.0	2.7			45.3	48.0	6.7		
F	14.7	72.0	26.7	1.3			53.0	40.3	6.6	0.1	
G	15.5	73.3	26.7				43.0	51.2	5.7	0.1	
N	15.6	80.7	17.3	2.0			48.1	46.6	5.3		
D	16.2	78.0	21.3	0.7			47.7	47.3	5.0		
M	16.7	74.7	24.0	1.3			41.9	48.2	9.3	0.6	
J	16.9	63.3	34.7	2.0			58.4	36.9	4.5	0.2	
P	17.2	78.7	21.3				46.7	48.9	4.4		
H	17.9	97.3	2.7				73.3	26.7			

Table 3. Mean rating across all observers and trials (N = 75) and cumulative percent of absolute difference in trials both within (N = 15 observers * 10 paired reps per observer = 150) and between (N = 15 observers * (5 reps * 70 other trials)/2 = 2625) observers.

Scratch	Mean Rating (N = 75)	Cumulative Percent of Absolute Difference in Trials									
		Within Observers (N = 150)					Between Observers (N = 2625)				
		0	1	2	3	4	0	1	2	3	4
K	11.5	80.0	97.3	100			45.7	84.8	98.2	100	
E	11.6	70.0	99.3	100			38.3	85.2	100		
O	11.8	64.0	98.7	100			33.2	69.8	94.2	100	
A	12.5	64.0	96.0	100			36.3	79.8	98.7	100	
I	12.6	56.7	92.0	96.0	99.3	100	24.7	67.5	92.7	99.7	100
L	13.0	58.7	96.7	99.3	100		28.8	76.0	97.4	99.9	100
C	13.4	67.3	98.0	100			27.7	69.2	92.5	99.3	100
B	14.0	73.3	97.3	100			45.3	93.3	100		
F	14.7	72.0	98.7	100			53.0	93.3	99.9	100	
G	15.5	73.3	100				43.0	94.2	99.9	100	
N	15.6	80.7	98.0	100			48.1	94.7	100		
D	16.2	78.0	99.3	100			47.7	95.0	100		
M	16.7	74.7	98.7	100			41.9	90.1	99.4	100	
J	16.9	63.3	98.0	100			58.4	95.3	99.8	100	
P	17.2	78.7	100				46.7	95.6	100		
H	17.9	97.3	100				73.3	100			

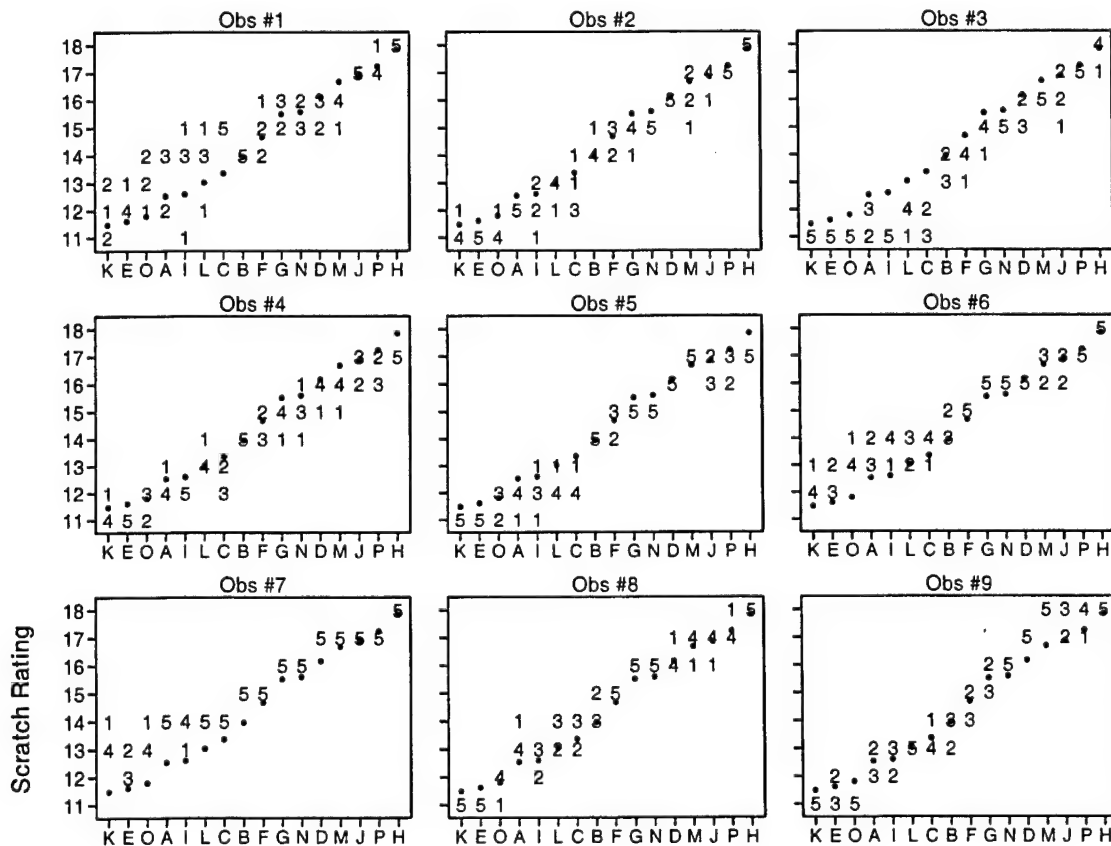
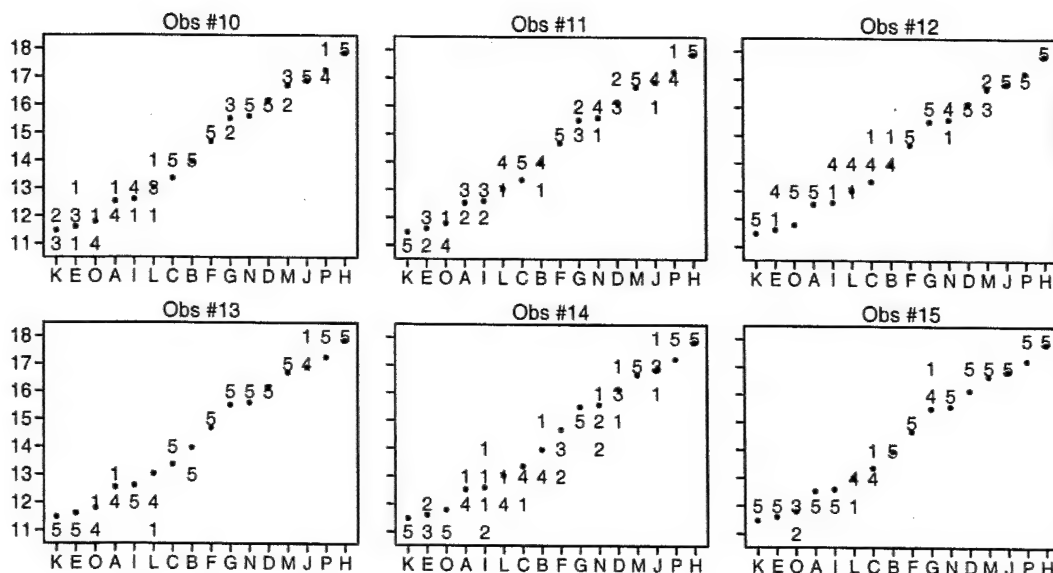


Figure 2a. Number of trials for observers 1-9 and scratch (N = 5) having a particular scratch rating.



Legend is number of trials
 • Mean across observers and trials

Scratch

Figure 2b. Number of trials for observers 10-15 and scratch (N = 5) having a particular scratch rating.

8. RESEARCH REPORT SUMMARY

Standard repeatability and reproducibility analyses (ASTM E 691) cannot be applied to these data since they are discrete instead of continuous. The cumulative percent of the absolute difference in trials data shown in Table 3 best delineate the within-laboratory (observer) and between-laboratory variability that may be expected for this test method.

9. PRECISION and BIAS

Precision - The repeatability of judging the intensity of a scratch within one scratch value, for the same observer, is 92% or better.

The reproducibility (between observers) of judging the intensity of a scratch within one scratch value is 90% or better for scratch values 14 and above. The reproducibility of judging the intensity of a scratch within two scratch values is 92% or better for scratch values below 14. The data reflect that it is more difficult to judge finer scratches.

Bias - The procedure in this test method has no bias because the scratch intensity is defined only in terms of the test method.

APPENDIX A

Data report forms:

ASTM Intensity of Scratches in Plastic Interlaboratory Study Data Sheet						
Initials: ...				Observer #: 1		
Date: _____						
Organization: _____						
Trial#	Scratch Sample	Rating		Trial#	Scratch Sample	Rating
1	K	11		41	H	18
2	I	11		42	C	15
3	O	12		43	N	16
4	L	12		44	J	17
5	D	13		45	L	14
6	N	15		46	K	13
7	G	16		47	G	16
8	H	18		48	F	15
9	P	17		49	M	16
10	E	12		50	O	14
11	F	14		51	D	16
12	B	14		52	A	14
13	K	11		53	C	15
14	A	12 12		54	B	14
15	J	17		55	J	17
16	M	15		56	E	12
17	L	14		57	N	15
18	N	16		58	I	14
19	C	15		59	K	12
20	P	18		60	P	17
21	O	13		61	O	13
22	I	14		62	M	16
23	G	15		63	A	14
24	F	15		64	H	18
25	E	12		65	D	16
26	D	16		66	B	14
27	J	17		67	F	14
28	B	14		68	C	15
29	L	14		69	E	12
30	H	18		70	G	15
31	K	13		71	P	17
32	A	14		72	L	15
33	O	14		73	J	17
34	G	16		74	N	15
35	M	16		75	I	15
36	I	14		76	A	12
37	F	16		77	M	16
38	E	13		78	D	15
39	P	17		79	H	18
40	B	14		80	C	15

APPENDIX A (continued)

ASTM Intensity of Scratches in Plastic Interlaboratory Study Data Sheet						
Initials: _____				Observer #: 2		
Date: _____						
Organization: _____						
Trial#	Scratch Sample	Rating		Trial#	Scratch Sample	Rating
1	O	11		41	H	18
2	F	14		42	M	17
3	C	12		43	P	17
4	J	17		44	D	16
5	E	11		45	I	13
6	D	16		46	B	14
7	M	17		47	C	13
8	I	12		48	G	15
9	P	17		49	L	13
10	A	12		50	N	15
11	K	11		51	A	12
12	N	15		52	J	17
13	H	18		53	H	18
14	O	11		54	O	12
15	J	17		55	F	15
16	B	15		56	K	12
17	C	12		57	I	11
18	G	15		58	B	14
19	L	13		59	D	16
20	D	16		60	L	13
21	P	17		61	E	11
22	F	15		62	M	16
23	E	11		63	A	12
24	H	18		64	N	15
25	M	16		65	G	15
26	K	11		66	C	12
27	I	12		67	K	11
28	O	11		68	F	14
29	B	14		69	J	16
30	A	12		70	I	13
31	D	16		71	P	17
32	P	17		72	B	14
33	J	17		73	L	13
34	C	14		74	M	15
35	N	15		75	E	11
36	G	15		76	A	12
37	L	12		77	G	14
38	E	11		78	K	11
39	O	11		79	N	15
40	F	15		80	H	18

APPENDIX A (continued)

ASTM Intensity of Scratches in Plastic Interlaboratory Study Data Sheet						
Initials: _____				Observer #: 3		
Date: _____						
Organization: _____						
Trial#	Scratch Sample	Rating		Trial#	Scratch Sample	Rating
1	B	13		41	B	13
2	J	17		42	O	11
3	M	16		43	F	13
4	I	11		44	L	11
5	G	15		45	I	11
6	N	15		46	D	15
7	H	17		47	E	11
8	A	12		48	J	16
9	K	11		49	A	12
10	L	12		50	G	14
11	C	11		51	C	11
12	E	11		52	N	15
13	D	15		53	M	16
14	B	14		54	O	11
15	O	11		55	F	14
16	G	15		56	B	13
17	M	16		57	P	17
18	I	11		58	D	15
19	N	15		59	H	18
20	K	11		60	K	11
21	P	17		61	A	12
22	J	16		62	I	11
23	H	18		63	L	12
24	C	12		64	M	16
25	D	16		65	N	15
26	O	11		66	F	14
27	A	11		67	J	15
28	M	16		68	E	11
29	F	14		69	P	17
30	B	14		70	G	15
31	N	15		71	D	16
32	L	12		72	C	11
33	J	17		73	A	11
34	I	11		74	K	11
35	E	11		75	O	11
36	C	12		76	H	18
37	P	17		77	F	14
38	H	18		78	L	12
39	G	15		79	E	11
40	K	11		80	P	17

APPENDIX A (continued)

ASTM Intensity of Scratches in Plastic Interlaboratory Study Data Sheet						
Initials: _____				Observer #: 4		
Date: _____						
Organization: _____						
Trial#	Scratch Sample	Rating		Trial#	Scratch Sample	Rating
1	F	15		41	K	11
2	N	16		42	O	12
3	O	11		43	C	13
4	E	11		44	A	13
5	P	17		45	B	14
6	J	16		46	E	11
7	C	13		47	L	14
8	B	14		48	F	14
9	K	11		49	H	17
10	L	13		50	D	16
11	A	12		51	J	17
12	I	12		52	I	12
13	M	16		53	K	11
14	F	14		54	O	12
15	D	15		55	G	15
16	O	12		56	M	16
17	G	14		57	N	15
18	H	17		58	E	11
19	E	11		59	B	14
20	N	14		60	C	12
21	J	16		61	L	13
22	L	13		62	F	15
23	B	14		63	H	17
24	P	16		64	P	16
25	I	12		65	A	12
26	C	12		66	D	16
27	D	16		67	M	16
28	M	15		68	G	15
29	F	14		69	E	11
30	K	11		70	J	17
31	O	11		71	K	12
32	A	12		72	B	14
33	G	15		73	C	12
34	H	17		74	I	12
35	N	15		75	P	16
36	L	13		76	H	17
37	J	17		77	D	16
38	P	17		78	A	12
39	M	16		79	N	15
40	I	12		80	G	15

APPENDIX A (continued)

ASTM Intensity of Scratches in Plastic Interlaboratory Study Data Sheet						
Initials: _____				Observer #: 5		
Date: _____						
Organization: _____						
Trial#	Scratch Sample	Rating		Trial#	Scratch Sample	Rating
1	P	16		41	B	14
2	M	17		42	H	17
3	I	11		43	F	15
4	A	11		44	I	12
5	E	11		45	C	12
6	K	11		46	A	12
7	L	12		47	K	11
8	D	16		48	D	16
9	B	14		49	J	17
10	N	15		50	P	17
11	F	14		51	E	11
12	H	17		52	G	15
13	P	16		53	L	13
14	G	15		54	N	15
15	J	16		55	B	14
16	M	17		56	M	17
17	O	11		57	H	17
18	C	12		58	O	12
19	E	11		59	A	12
20	B	14		60	C	13
21	A	12		61	D	16
22	K	11		62	P	17
23	D	16		63	K	11
24	N	15		64	G	15
25	H	17		65	F	15
26	L	12		66	J	16
27	J	16		67	B	14
28	F	14		68	I	13
29	O	12		69	O	12
30	C	12		70	L	12
31	P	17		71	A	12
32	I	12		72	C	12
33	M	17		73	E	11
34	K	11		74	M	17
35	D	16		75	G	15
36	N	15		76	N	15
37	L	12		77	F	15
38	J	17		78	H	17
39	E	11		79	I	12
40	G	15		80	O	11

APPENDIX A (continued)

ASTM Intensity of Scratches in Plastic Interlaboratory Study Data Sheet						
Initials:				Observer #: 6		
Date:						
Organization:						
Trial#	Scratch Sample	Rating		Trial#	Scratch Sample	Rating
1	O	13		41	D	16
2	M	17		42	K	12
3	L	13		43	E	13
4	H	15		44	F	15
5	J	17		45	O	13
6	F	15		46	J	17
7	E	12		47	H	15
8	B	15		48	A	13
9	G	16		49	G	16
10	P	17		50	L	13
11	A	14		51	B	14
12	K	12		52	I	14
13	C	13		53	N	12
14	N	16		54	K	12
15	D	16		55	M	12
16	H	15		56	F	15
17	F	15		57	J	16
18	I	13		58	H	15
19	B	14		59	O	14
20	E	13		60	C	14
21	P	17		61	D	16
22	G	16		62	P	17
23	M	17		63	B	14
24	C	14		64	I	14
25	L	15		65	A	13
26	K	12		66	K	12
27	N	16		67	L	14
28	F	15		68	E	12
29	I	14		69	H	15
30	D	16		70	M	16
31	E	12		71	N	12
32	O	13		72	D	16
33	J	17		73	C	14
34	A	13		74	G	16
35	G	16		75	I	14
36	C	14		76	A	14
37	M	17		77	J	16
38	B	15		78	O	13
39	P	17		79	P	17
40	N	16		80	L	16

APPENDIX A (continued)

ASTM Intensity of Scratches in Plastic Interlaboratory Study Data Sheet						
Initials: _____				Observer #: 7		
Date: _____						
Organization: _____						
Trial#	Scratch Sample	Rating		Trial#	Scratch Sample	Rating
1	G	16		41	P	17
2	F	15		42	N	16
3	H	18		43	M	17
4	C	14		44	F	15
5	D	17		45	J	17
6	E	13		46	H	13
7	K	14		47	L	14
8	M	17		48	G	16
9	O	14		49	A	14
10	P	17		50	E	12
11	B	15		51	B	15
12	I	14		52	P	17
13	F	15		53	O	13
14	L	14		54	N	16
15	C	14		55	K	13
16	H	18		56	I	13
17	E	12		57	M	17
18	G	16		58	J	17
19	A	14		59	D	17
20	M	17		60	A	14
21	O	13		61	G	16
22	P	17		62	B	15
23	K	13		63	E	13
24	D	17		64	L	14
25	B	15		65	N	16
26	I	14		66	P	17
27	J	17		67	C	14
28	N	16		68	M	17
29	L	14		69	J	17
30	G	16		70	I	14
31	F	15		71	F	15
32	A	14		72	H	18
33	O	13		73	D	17
34	H	18		74	A	14
35	C	14		75	L	14
36	B	15		76	O	13
37	D	17		77	N	16
38	E	12		78	C	14
39	I	14		79	K	13
40	K	13		80	J	17

APPENDIX A (continued)

ASTM Intensity of Scratches in Plastic Interlaboratory Study Data Sheet						
Initials: _____				Observer #: 8		
Date: _____						
Organization: _____						
Trial#	Scratch Sample	Rating		Trial#	Scratch Sample	Rating
1	G	16		41	O	11
2	H	13		42	D	16
3	C	13		43	H	18
4	I	12		44	J	17
5	K	11		45	A	13
6	P	18		46	P	17
7	D	17		47	N	16
8	J	16		48	G	16
9	M	17		49	L	14
10	L	13		50	E	11
11	N	16		51	M	16
12	B	15		52	I	13
13	E	11		53	K	11
14	F	15		54	D	16
15	O	12		55	H	18
16	C	13		56	O	12
17	H	18		57	A	13
18	K	11		58	B	14
19	J	17		59	P	17
20	P	17		60	F	15
21	A	14		61	L	13
22	N	16		62	E	11
23	D	16		63	C	14
24	B	15		64	K	11
25	I	13		65	G	16
26	G	16		66	I	13
27	C	14		67	M	17
28	F	15		68	A	13
29	H	18		69	O	12
30	E	11		70	J	17
31	J	17		71	D	16
32	K	11		72	L	14
33	N	16		73	F	15
34	L	14		74	B	14
35	P	17		75	N	16
36	M	17		76	E	11
37	G	16		77	I	12
38	C	14		78	M	17
39	B	14		79	A	13
40	F	15		80	O	12

APPENDIX A (continued)

ASTM Intensity of Scratches in Plastic Interlaboratory Study Data Sheet						
Initials: _____				Observer #: 9		
Date: _____						
Organization: _____						
Trial#	Scratch Sample	Rating		Trial#	Scratch Sample	Rating
1	O	11		41	P	18
2	B	13		42	O	11
3	L	13		43	M	18
4	E	12		44	I	13
5	J	18		45	A	12
6	A	12		46	F	14
7	G	16		47	N	16
8	I	12		48	C	13
9	H	18		49	J	18
10	C	13		50	K	11
11	K	11		51	E	18
12	D	17		52	P	18
13	O	11		53	D	17
14	B	14		54	M	18
15	M	18		55	B	14
16	E	11		56	I	13
17	N	16		57	A	13
18	G	15		58	F	15
19	F	15		59	C	13
20	A	12		60	G	15
21	P	18		61	L	13
22	L	13		62	E	11
23	H	18		63	O	11
24	J	17		64	D	17
25	I	12		65	P	18
26	O	11		66	K	11
27	D	17		67	M	18
28	N	16		68	N	16
29	M	18		69	H	18
30	C	13		70	J	17
31	B	13		71	G	16
32	F	14		72	I	13
33	L	13		73	C	14
34	A	13		74	B	14
35	J	18		75	F	14
36	K	11		76	L	13
37	H	18		77	P	17
38	E	11		78	K	11
39	D	17		79	N	16
40	G	15		80	H	18

APPENDIX A (continued)

ASTM Intensity of Scratches in Plastic Interlaboratory Study Data Sheet					
Initials: _____			Observer #: 10		
Date: _____					
Organization: _____					
Trial#	Scratch Sample	Rating	Trial#	Scratch Sample	Rating
1	C	14	41	H	18
2	E	12	42	B	14
3	K	12	43	I	13
4	L	12	44	J	17
5	M	17	45	K	11
6	H	18	46	G	16
7	J	17	47	O	11
8	N	16	48	A	12
9	P	18	49	M	17
10	B	14	50	L	13
11	D	16	51	D	16
12	I	12	52	P	17
13	O	11	53	H	18
14	G	16	54	F	15
15	L	13	55	B	14
16	M	16	56	I	13
17	C	14	57	N	16
18	J	17	58	C	14
19	E	12	59	G	15
20	A	13	60	A	12
21	F	15	61	J	17
22	H	18	62	D	16
23	N	16	63	P	17
24	P	17	64	O	11
25	G	15	65	F	15
26	L	14	66	E	12
27	D	16	67	M	17
28	I	13	68	K	11
29	B	14	69	N	16
30	K	12	70	I	13
31	J	17	71	B	14
32	M	16	72	L	13
33	O	11	73	A	12
34	C	14	74	H	18
35	N	16	75	O	12
36	E	11	76	G	16
37	A	12	77	C	14
38	D	16	78	E	13
39	P	17	79	F	15
40	F	15	80	K	11

APPENDIX A (continued)

ASTM Intensity of Scratches in Plastic Interlaboratory Study Data Sheet						
Initials: _____				Observer #: 11		
Date: _____						
Organization: _____						
Trial#	Scratch Sample	Rating		Trial#	Scratch Sample	Rating
1	K	11		41	G	15
2	I	12		42	I	13
3	P	18		43	F	15
4	M	17		44	O	12
5	F	15		45	H	18
6	O	11		46	E	12
7	G	16		47	D	16
8	A	12		48	L	14
9	C	14		49	C	14
10	H	18		50	K	11
11	L	13		51	J	16
12	D	17		52	B	14
13	E	11		53	N	15
14	B	13		54	M	17
15	K	11		55	F	15
16	P	17		56	A	13
17	N	16		57	G	16
18	G	15		58	I	13
19	M	17		59	E	11
20	J	17		60	H	18
21	H	18		61	C	14
22	L	14		62	O	11
23	A	13		63	P	17
24	C	14		64	D	16
25	F	15		65	M	17
26	O	11		66	N	16
27	B	14		67	J	17
28	D	16		68	A	13
29	P	17		69	L	14
30	I	12		70	G	15
31	M	17		71	K	11
32	E	12		72	B	14
33	L	14		73	F	15
34	H	18		74	E	12
35	C	14		75	O	11
36	N	16		76	I	13
37	K	11		77	N	16
38	J	17		78	J	17
39	B	14		79	D	17
40	P	17		80	A	12

APPENDIX A (continued)

ASTM Intensity of Scratches in Plastic Interlaboratory Study Data Sheet					
Initials: _____			Observer #: 12		
Date: _____					
Organization: _____					
Trial#	Scratch Sample	Rating	Trial#	Scratch Sample	Rating
1	G	16	41	O	13
2	M	17	42	H	18
3	I	14	43	P	17
4	N	16	44	A	13
5	B	15	45	J	17
6	L	14	46	F	15
7	C	15	47	D	16
8	O	13	48	N	15
9	K	12	49	L	13
10	P	17	50	M	16
11	D	16	51	K	12
12	E	13	52	G	16
13	G	16	53	E	13
14	A	13	54	B	14
15	F	15	55	P	17
16	J	17	56	I	13
17	B	14	57	H	18
18	H	18	58	A	13
19	L	14	59	O	13
20	N	16	60	L	14
21	I	14	61	D	16
22	M	17	62	J	17
23	E	13	63	M	16
24	O	13	64	N	16
25	G	16	65	C	14
26	C	14	66	F	15
27	K	12	67	E	13
28	D	16	68	G	16
29	A	13	69	P	17
30	H	18	70	A	13
31	L	14	71	H	18
32	J	17	72	D	16
33	F	15	73	J	17
34	N	16	74	B	14
35	E	12	75	O	13
36	B	14	76	I	14
37	C	14	77	K	12
38	M	16	78	C	14
39	K	12	79	F	15
40	I	14	80	P	17

APPENDIX A (continued)

ASTM Intensity of Scratches in Plastic Interlaboratory Study Data Sheet					
Initials: _____			Observer #: 13		
Date: _____					
Organization: _____					
Trial#	Scratch Sample	Rating	Trial#	Scratch Sample	Rating
1	C	14	41	A	12
2	L	12	42	P	18
3	N	16	43	B	13
4	F	15	44	H	18
5	K	11	45	L	12
6	G	16	46	J	17
7	D	16	47	M	17
8	H	18	48	I	12
9	M	17	49	K	11
10	B	13	50	C	14
11	J	17	51	N	16
12	O	11	52	E	11
13	P	18	53	G	16
14	L	12	54	A	12
15	C	14	55	D	16
16	K	11	56	F	15
17	I	12	57	O	11
18	D	16	58	P	18
19	G	16	59	I	12
20	H	18	60	J	17
21	N	16	61	M	17
22	E	11	62	K	11
23	A	13	63	C	14
24	P	18	64	L	12
25	L	11	65	A	12
26	O	12	66	B	13
27	J	18	67	E	11
28	F	15	68	N	16
29	B	13	69	F	15
30	M	17	70	G	16
31	H	18	71	I	12
32	I	12	72	J	17
33	N	16	73	M	17
34	G	16	74	P	18
35	D	16	75	O	11
36	K	11	76	H	18
37	E	11	77	B	13
38	C	14	78	D	16
39	O	11	79	A	12
40	F	15	80	E	11

APPENDIX A (continued)

ASTM Intensity of Scratches in Plastic Interlaboratory Study Data Sheet						
Initials: _____				Observer #: 14		
Date: _____						
Organization: _____						
Trial#	Scratch Sample	Rating		Trial#	Scratch Sample	Rating
1	N	14		41	J	18
2	O	11		42	B	13
3	L	13		43	M	17
4	A	12		44	F	14
5	M	17		45	P	18
6	I	14		46	L	12
7	D	16		47	H	18
8	K	11		48	G	15
9	G	13		49	C	13
10	E	12		50	O	11
11	H	18		51	I	12
12	C	13		52	N	15
13	F	13		53	A	13
14	J	17		54	J	17
15	B	13		55	E	12
16	L	12		56	D	16
17	P	18		57	K	11
18	O	11		58	P	18
19	A	12		59	G	15
20	N	16		60	C	13
21	G	15		61	B	13
22	E	11		62	F	14
23	H	18		63	N	14
24	M	17		64	L	12
25	K	11		65	O	11
26	D	17		66	M	17
27	I	13		67	E	11
28	P	18		68	K	11
29	B	15		69	D	15
30	J	16		70	H	18
31	L	12		71	P	18
32	N	15		72	G	15
33	F	13		73	A	12
34	H	18		74	C	13
35	O	11		75	F	14
36	C	12		76	B	13
37	A	12		77	J	17
38	I	11		78	M	17
39	E	11		79	K	11
40	D	16		80	I	11

APPENDIX A (continued)

ASTM Intensity of Scratches in Plastic Interlaboratory Study Data Sheet						
Initials: _____				Observer #: 15		
Date: _____						
Organization: _____						
Trial#	Scratch Sample	Rating		Trial#	Scratch Sample	Rating
1	G	16		41	I	12
2	A	12		42	P	18
3	J	17		43	J	17
4	N	16		44	A	12
5	L	12		45	C	13
6	F	15		46	F	15
7	I	12		47	N	16
8	M	17		48	G	16
9	B	14		49	O	12
10	D	17		50	K	12
11	K	12		51	E	12
12	C	14		52	H	18
13	O	11		53	D	17
14	A	12		54	L	13
15	P	18		55	A	12
16	E	12		56	C	13
17	N	16		57	M	17
18	J	17		58	P	18
19	I	12		59	F	15
20	F	15		60	I	12
21	M	17		61	O	12
22	L	13		62	B	14
23	H	18		63	K	12
24	B	14		64	H	18
25	G	16		65	N	16
26	C	13		66	G	16
27	E	12		67	D	17
28	D	17		68	L	13
29	J	17		69	J	17
30	K	12		70	E	12
31	P	18		71	C	13
32	F	15		72	M	17
33	A	12		73	O	11
34	O	12		74	I	12
35	M	17		75	B	14
36	N	16		76	P	18
37	B	14		77	K	12
38	E	12		78	D	17
39	H	18		79	G	17
40	L	13		80	H	18

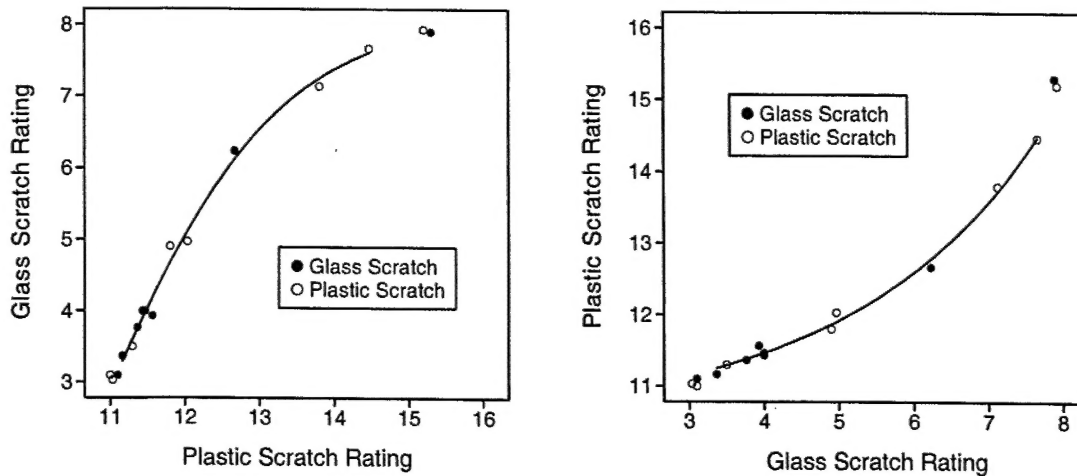
APPENDIX B (Non-mandatory Information)

Comparison of Glass and Plastic Scratch Ratings

A study was performed to determine equivalent relationships between glass and plastic scratch adjuncts. This empirically derived relationship can be used if needed when: (1) only glass adjuncts are available to judge the intensity of scratches in plastic, (2) only plastic adjuncts are available to judge the intensity of scratches in glass or (3) it is desirable to convert the between the glass and plastic scales.

Five trained observers rated eight glass and eight plastic scratches. Each scratch was rated using both glass and plastic adjuncts three times. The 96 trials for each observer were randomized with the constraint that there be at least five trials between replications of the same scratch and either glass or plastic adjunct. Figure 3 shows the number of trials for each observer and scratch having a particular scratch rating.

Figure 1 contains the estimated relationship between the glass (G) and plastic (P) scratch ratings and between the plastic and glass ratings. Table 1 and Figure 2 contain the mean scratch rating for each scratch.



$$G = 8.06 \left(1 - e^{-\left(\frac{P - 9.48}{2.54} \right)^{1.57}} \right)$$

$$P = 9.76 + e^{\left(\frac{G}{5.86} \right)^{1.64}}$$

Figure 1. Non-linear regression fit of mean scratch ratings (N = 15). The 3 means near (P = 11, G = 3) and the 2 means near (P = 15, G = 8) were not used since they contained multiple trials where the glass rating was either 3- or 8+.

Table 1. Mean glass and plastic scratch rating for each scratch (N = 15). Ratings are sorted by glass adjunct.

Scratch Material	Scratch	Mean Rating (N = 15)	
		Glass Adjunct	Plastic Adjunct
Glass	D	3.1	11.1
	A	3.4	11.2
	I	3.8	11.4
	L	3.9	11.6
	B	4.0	11.5
	F	4.0	11.4
	E	6.2	12.7
	G	7.9	15.3
Plastic	O	3.0	11.0
	I	3.1	11.0
	C	3.5	11.3
	A	4.9	11.8
	L	5.0	12.0
	B	7.1	13.8
	F	7.7	14.5
	G	7.9	15.2

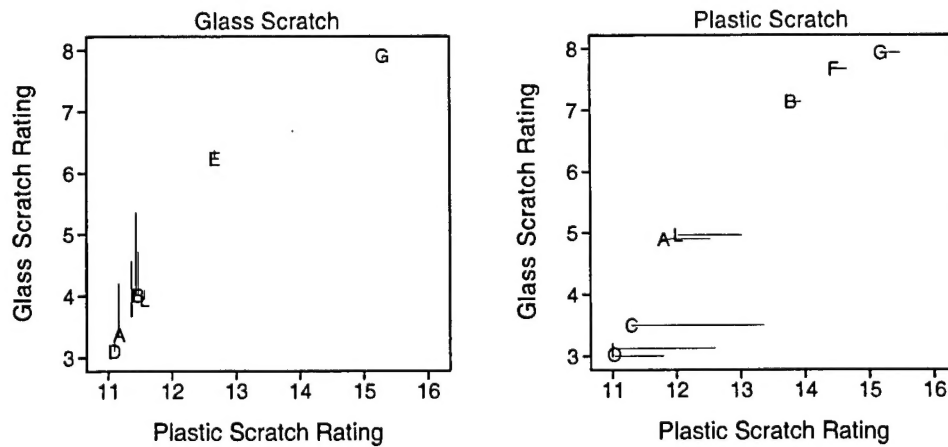


Figure 2. Mean glass and plastic scratch rating for each scratch (N = 15). Solid line segments connect means in this study with means from previous studies involving glass or plastic only.

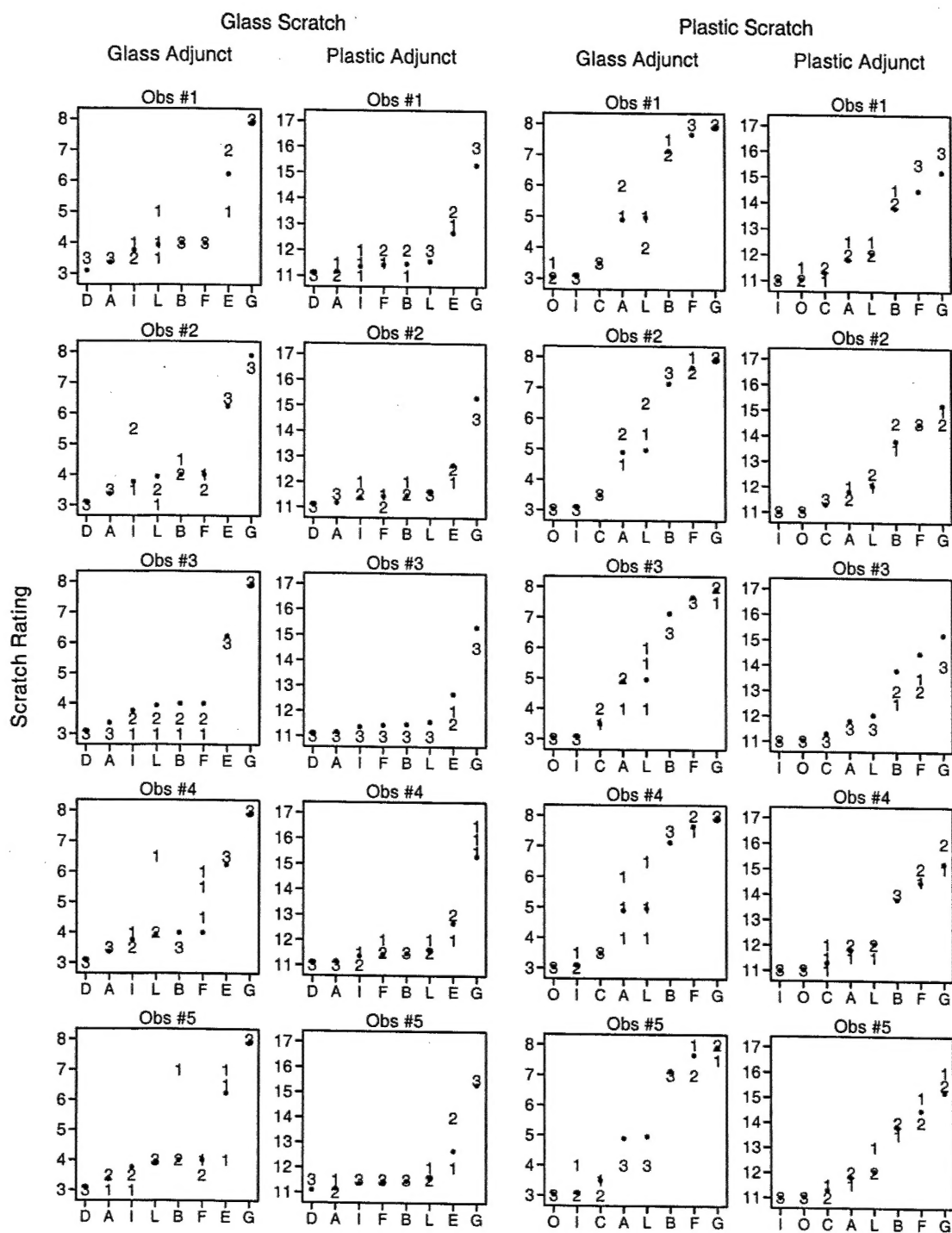


Figure 3. Number of trials for each observer and scratch (N = 3) having a particular scratch rating when compared with either glass or plastic adjunct.